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Title: Isotopic Ratios of Samarium by TIMS for Nuclear Forensic Application

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Isotopic Ratios of Samarium by TIMS for Nuclear Forensic Application

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James Louis-Jean (C-NR, TA-48,0045)

- **Educational Background**
  - BA, Florida Memorial University, 2014
  - PhD, 3rd year, University of Nevada-Las Vegas, 2015-present

Research Group/Mentor

- *C-NR: Nuclear & Radiochemistry*
  - *Mass Spectrometry & Clean Chemistry Lab*
  - Jeremy D. Inglis, PhD

James Louis-Jean

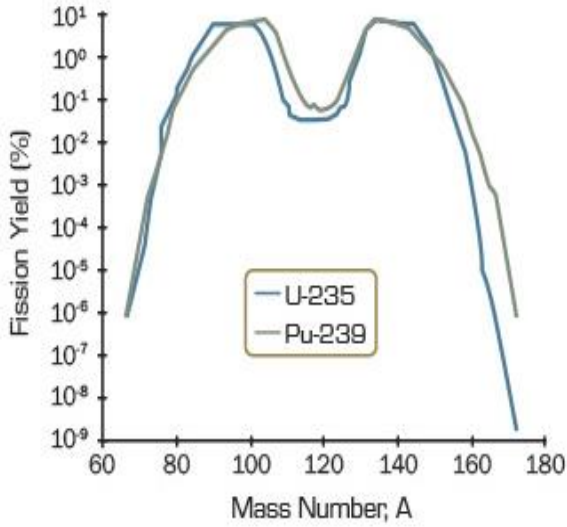
Dr. Jeremy Inglis

- **Research Topics**
  - Summer Research Topic: Isotopic Ratios of Samarium by TIMS for Nuclear Forensic Application
  - Thesis Topic: Fundamental Chemistry of ^{99}Tc for Nuclear Waste Application

Research Overview and Motivation

- **Nuclear forensics: evidence of nuclear materials (NMs), trafficking, enrichment, and signatures.**
- **Various form of material can be recovered for evidence: dust and radioactive debris.**
- **In nuclear devices, the neutron induced fission of 235U and 239Pu produce various rare earth elements (REEs).**

- **Nd, Sm, and Gd are produced in measurable quantities in non-natural isotopic abundances.**
- **They have many stable isotopes with high thermal neutron cross sections (>1000b).**
- **Results in depletion of isotopes with large cross (^{149}Sm) sections and enrichment of isotopes of those with low cross sections; consequently proportional to the neutron fluence.**

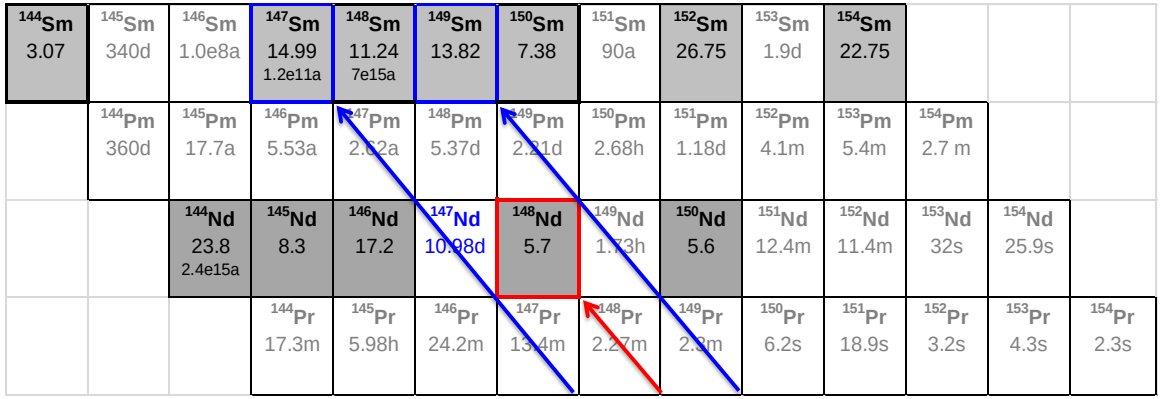


Research Overview and Motivation

- **The isotopic ratio of Nd, Sm, and Gd can provide important information regarding fissile material (nuclear devices, reactors), neutron environment, and device yield.**
- **These studies require precise measurement of Sm isotope ratios, by either TIMS or MC-ICP-MS.**
- **There has been an increasing trend to measure smaller and smaller quantities of Sm bearing samples.**
- **In nuclear forensics 10-100 ng of Sm are needed for precise measurement.**

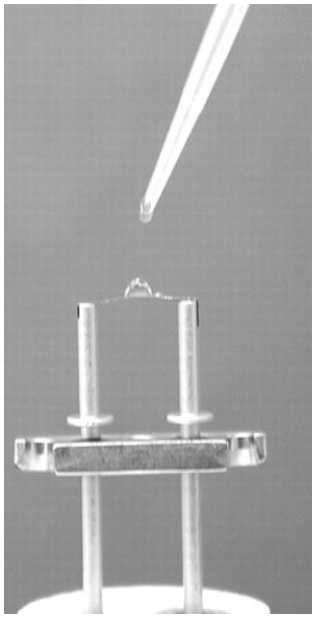
Goal

→To measure sub-ng Sm samples using TIMS for nuclear forensic analysis.



Research Approach

- **Different recipes for Sm ions emission**
  - H_2O:Pt/Re solution
    → 5-1; 10-1; 20-1; 30-1
  - Samarium standard (2 ng/µL)
  - H_3PO_4 (0.1 N): 1 µL
- **Samples Prep:**
  - Samples were loaded on degassed Re filaments:
    → (1^{st}: H_3PO_4; 2^{nd}: Pt/Re; 3^{rd}: Sm std)
- **Measurements:**
  - Samples were measured on a GV IsoprobeT in static mode using 7 Faraday collector cups.



Summary of Results

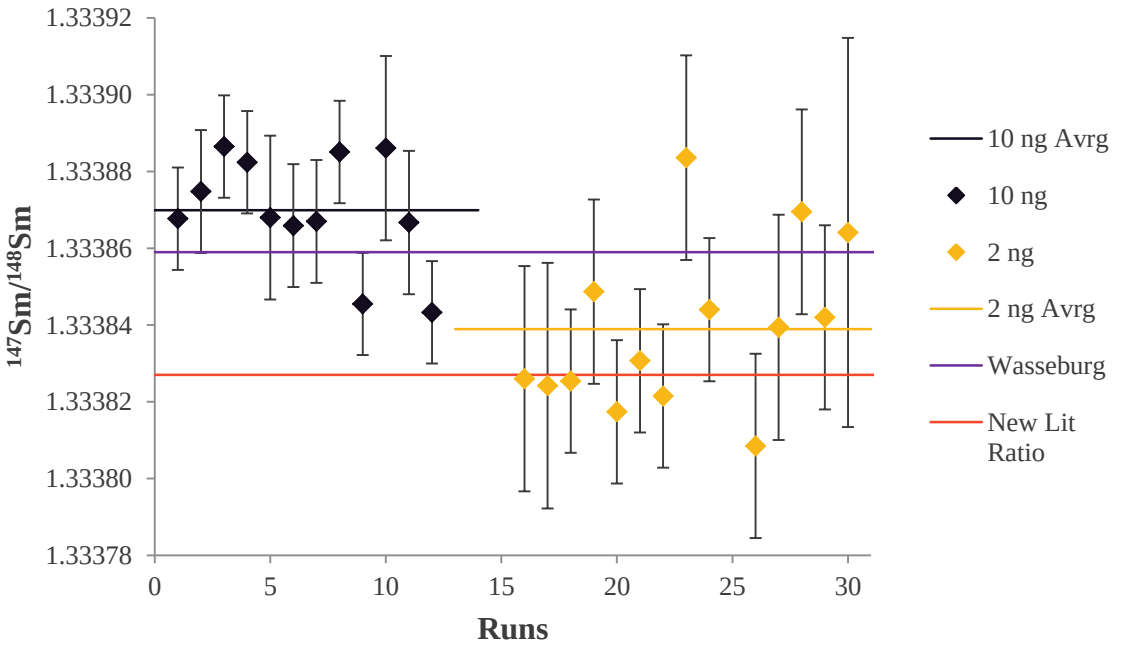
	*2 ng Sm Std Pt/Re				10 ng Sm Std
	5-1	10-1	20-1	30-1	TaF gel
Average	1.333845	1.3338352	1.3338456	1.3338381	1.333869917
2std	5.47E-05	3.21E-05	4.45E-05	4.51E-05	2.88905E-05
ppm	41.042351	24.101456	33.397234	33.789168	21.65915356
Wasserburg	1.333859				
New Lit. Ratio	1.333827				

Samples loaded with the Pt/Re 10-1 solution showed better result.

- Load size: 2ng Sm std
- $^{147}Sm/^{148}Sm$ isotopic ratio

Different load sizes and recipes

- **2 ng Sm std with Pt/Re (10:1)**
  - ➢ Show better agreement with the new literature reported ratios (newly accepted).
- **10 ng Sm std with TaF**
  - ➢ Show better agreement with Wasserburg (previously accepted ratio).



Conclusion

- **Measured sub-ng of Sm by TIMS.**
  - → 2 ng of Sm std
- **Investigated an effort to make precise Sm isotopic measurements.**
  - → Pt/Re loading recipes
- **Improved the amount of materials which can be analyze for forensic.**
  - → Trinitite: 100 ng Sm/ g
- **Possibility to determine the number of fissions by measuring stable isotopes of Sm.**
  - → Samrium: $^{144, 147, 148, 149, 150, 152, 154}$Sm
  - → ^{149}Sm: high neutron cross section (~40,400 barns at 0.025eV)
  - → ^{149}Sm(n,γ)^{150}Sm

FUTURE DIRECTIONS

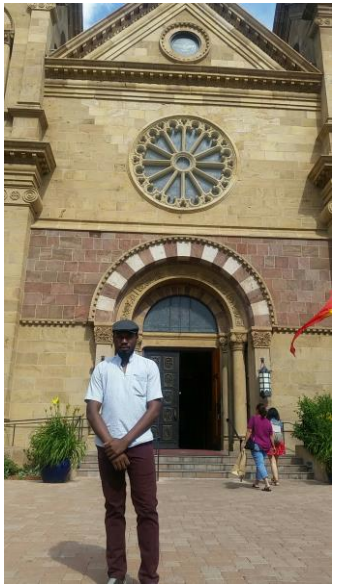
- **Continue to investigate the Pt/Re 5:1 recipes.**
- **Study and compare other recipes**
  - → TaF/H_3PO_4; TaF/Pt; Pt/Re /H_3PO_4

Acknowledgments & Summer Fun

Acknowledgments

- Los Alamos National Laboratory; *C-NR: Nuclear & Radiochemistry; Mass Spectrometry & Clean Chemistry Lab*
- Dr. Jeremy D. Inglis
- Nuclear Science & Security Consortium, *NSSC*

Santa Fe exploration.
Picture by: Maria Pinilla



Santa Fe exploration.
Picture by: Maria Pinilla

Backyard deer watching after work.

Fourth of July celebration